

SECTION 1202

LINE SHAFT DRIVEN VERTICAL TURBINE WELL PUMPS (OIL LUBRICATED)

1202.0100 GENERAL

1202.0101 Description of Work. The work under this Section shall consist of furnishing all labor, materials, equipment, and appurtenances required for the installation and testing of line shaft driven vertical turbine well pumping unit assemblies. The pumping unit assembly shall include, but not be limited to:

- Line shaft driven vertical turbine pump
- Column pipe
- Oil tube
- Line shaft
- Suction pipe
- Intake screen
- Discharge head
- Vertical hollow shaft electric motor
- Related components.

The pumping unit assembly shall be provided by the pump manufacturer or his/her authorized representative. If provided by a factory-authorized representative, a letter from the pump manufacturer shall be provided certifying said authorization.

All wetted parts of the pumping unit assembly—including assembly lubricants—shall conform to the National Sanitation Foundation Standard (NSF) 61.

It is the intent of these specifications to obtain a pumping unit assembly of heavy-duty construction for heavy-duty service capable of pumping ground water for continuous service or for intermittent service, whichever imposes the most severe service on the pumping unit assembly.

All pumping unit assemblies shall be field tested. Pumps with mechanical defects or not meeting the range of head vs. capacity characteristics, horsepower, efficiency, and vibration requirements will be rejected after testing and shall be replaced without additional cost to the Owner for furnishing, removal, reinstallation and re-testing. Mechanical defects shall include the following:

- Excessive vibration, as determined by the Hydraulic Institute ANSI/HI 9.6.4-2000, and per Subsection 1202.0304
- Improper balancing of any rotating parts
- Improper tolerances
- Binding
- Excessive bearing heating

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- Defective materials, including materials that do not conform to the specifications
- Improper fitting of parts
- Any other defect that will, in time, damage the pump or unreasonably impair its efficiency

All necessary and desirable accessory equipment and auxiliaries, whether specifically mentioned in this Section or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of service. Also included shall be supervisory services during installation and field testing of each unit, and instructing the regular operating personnel in the proper care, operation, and maintenance of the equipment.

1202.0103. Submittals. All submittals shall reference the Tucson Water project plan number.

(A) Pumping Unit Assembly. Submittals shall detail each item of equipment and auxiliary apparatus to be furnished, and include the following:

- (1) Dimensional drawings together with literature showing the entire pumping unit assembly. Dimensional drawings shall include both plan and section views.
- (2) Pump make and model.
- (3) Number of stages in pump.
- (4) Pump bowl material and diameter, including ASTM specification compliance and pump bowl lining and coating specification.
- (5) Pump bowl bearing material.
- (6) Impeller type, material, and diameter.
- (7) Column pipe material and diameter.
- (8) Line shaft material and diameter.
- (9) Pump shaft material and diameter.
- (10) Pump bowl bearing to line shaft clearances with a note as to the maximum allowable clearance.
- (11) Pump bowl wear area to impeller skirt clearances with a note as to the maximum allowable clearance.
- (12) Installation, operation, and lubrication instructions.

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(13) Discharge head machine drawings detailing required penetrations and base circles per the requirements of this Section.

(14) Any other noteworthy design features.

(B) Pump Performance Curve. For each pump to be supplied, submittals shall furnish the actual pump performance curve for the fully assembled multistage pump and its specific impeller diameter. This shall include:

(1) Pump head and capacity curve

(2) Horsepower requirement curve

(3) Efficiency curve

(4) Thrust factor (K) curve

(5) NPSH curve

(6) Impeller lateral

(7) Recommended impeller setting

(8) Weights of the pumping unit components

(9) A statement of guarantee that the critical speed analyses as required under Subsection 1202.0304 have been completed and that the specified limitations will be met

Curves shall show the full recommended range of performance and include shutoff head. This information shall be prepared specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable; see sample at the end of this Section for required information and proper data plotting. Failure to comply with these requirements will result in rejection of the pump.

(C) Test Reports. Submittals shall include test reports on Shop Testing as specified in Subsections 1202.0305(A) and 1202.0201(H).

(D) Operation and Maintenance Data. Complete operating and maintenance instructions shall be furnished for all included equipment. The maintenance instructions shall include troubleshooting data and full preventative maintenance schedules, and complete spare parts lists with ordering information. Manuals shall be submitted prior to pump testing.

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1202.0104 Delivery, Storage, and Handling. All parts shall be properly protected such that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is complete and the unit and equipment are ready for operation.

All equipment and parts must be properly protected against any damage during shipment. Equipment shall be stored in accordance with the manufacturer's recommendations.

Factory-assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer. The vertical turbine pump bowl assembly shall be assembled and shipped as a single unit. A column pipe nipple long enough to cover the oil tube and line shaft stickup shall be installed to prevent any damage or strain to the pump shaft during shipping and storage.

The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted thereto.

Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

No shipment shall be made until written approval of the submittals has been received.

Bearings shall be properly processed to protect them during shipment and installation. If pre-lubricated, anti-friction bearings shall be protected in accordance with the bearing manufacturer's recommendations against formation of rust during a long period of storage while awaiting completion of installation and startup of the machine in which they are used.

If not pre-lubricated, anti-friction bearings shall be properly treated with the application of Exxon Rust-Ban No. 392, or equal, in accordance with the bearing manufacturer's recommendation against formation of rust during a long period of storage while awaiting completion of installation and startup.

1202.0200 PRODUCTS

1202.0201 Materials.

(A) Vertical Turbine Pumps.

(1) Standards. The vertical turbine pumps and the materials used in their manufacture shall comply with the most recent revision of the following standards unless otherwise specified:

See Table 1202-1 on the next page.

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Table 1202-1
Standards, Vertical Turbine Pumps

Subject	Standard Designation
Horizontal and Vertical Line Shaft Pumps	ANSI/AWWA E103-07
Protective Epoxy Interior Coatings for Valves and Hydrants	ANSI/AWWA C550
Steel Structures Painting Council Surface Preparation Specification No. 10	SSPC-SP-10/NACE 2
Suction and Discharge Cases (Flanged and Bolted)	Cast Iron ASTM A48 Class 30
Pump Bowl (Flanged and Bolted)	Cast iron ASTM A48 Class 30 Precision Close Grained Castings
Impellers (Enclosed)	Bronze ASTM B584-836
Pump Shaft (Bowl Shaft) and Couplings	ASTM A582 type 416 stainless steel PSQ
Discharge Case Bearing	ASTM B584-836 or ASTM B505-932
Suction Case Bearing	ASTM B584-836 or ASTM B505-932
Intermediate Bowl Bearing(s)	ASTM B584-836 or ASTM B505-932
Bowl Assembly Bolts, Studs, Nuts	ASTM A276 type 316 stainless steel

(2) Design. The vertical turbine pump's design shall conform to the specific requirements contained herein.

Vertical turbine pump bowl assembly shall be set up for oil-lubed line shaft configuration.

The vertical turbine pump shall be a single or multi-stage unit, as required, with enclosed impellers. Impellers shall be statically and dynamically balanced.

Vertical turbine well pumps shall be capable of operating at 150 percent of design head or shutoff head—whichever is less—for not less than 2 minutes without excessive vibration, binding, rubbing of rotating parts, or damage to the pump.

The pump shall be designed and constructed so that the standard lateral impeller adjustment shall exceed the calculated net line shaft stretch by at least 0.125 inch for the specified installation conditions.

The pump curve for the vertical turbine pump shall be as steep as practicable within the constraints of this section, and shall exhibit a continuously rising characteristic to shutoff head, with no points of zero slope reversal. The bowl's efficiency shall be as specified in the project plans and specifications at the design point.

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The pump's performance shall be measured at the pump's discharge bowl.

(3) Construction

(a) General. Overall unit construction shall conform to the following requirements:

- (1) Pump shall be constructed for operation with an enclosed line shaft.
- (2) The line shaft tubing adaptor shall be provided with deflector seals about the shaft to prevent water from entering the oil tube.
- (3) The pump shall be constructed with a 10-inch tube adaptor stickup and a 20-inch pump shaft stickup.
- (4) The tube adaptor, oil tube, line shaft, and pump shaft shall be machined to Johnston new style type dimensions and threading.

(b) Pump Bowls.

- (1) Pump bowls shall be free of blow holes, sand holes, and other defects.
- (2) Pump bowls shall be accurately machined and fitted.
- (3) Water passages of pump bowls size 6 inches through 14 inches shall have vitreous enamel lining. Water passages of pump bowls size 16 inches and larger shall be lined with fusion-bonded epoxy to provide optimum long-term performance. The outside of the bowl assembly shall be coated with an NSF-approved 2-part epoxy paint system.

(c) Pump Suction Case.

- (1) Pump suction case shall have integrated anti-vortex vanes to suppress vortex formation.
- (2) The bottom bearing housing in the suction case shall be cast as an integral part of the suction case.
- (3) The bottom bearing shall be a long bearing filled with non-soluble grease or lubricant that will not break down or dissolve.
- (4) The housing shall be equipped with a cap or plug to prevent the escape of grease or lubricant.

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(d) Pump Impellers.

- (1) Impellers shall be of the enclosed type.
- (2) Impellers shall be accurately machined to fit the matching faces of the bowls.
- (3) Impellers shall be both statically and dynamically balanced.
- (4) Impellers shall have non-overloading characteristics.
- (5) Impellers shall be free of casting imperfections.
- (6) Impeller castings shall be accurately machined with vanes carefully finished to ensure smooth passageways.
- (7) Impellers shall be fixed to the pump shaft with tapered stainless steel ASTM A276, type 316 lock collets.

(e) Pump Shaft.

- (1) Pump shafting shall be a one-piece solid shaft with self-tightening threaded connections conforming to ANSI 416 “pump shaft quality” (PSQ) stainless steel.
- (2) Pump shall be supplied with a 10-20 stickup.
- (3) Pump shaft inner columns shall be sized, machined, and threaded to Johnston standards.

(f) Suction Pipe and Strainer.

- (1) The pump shall be installed with a 10-foot long suction pipe of the same size and threads per inch as the pipe column.
- (2) The threading on the suction pipe where it attaches to the pump shall have tapered threads.
- (3) The lower end of the suction pipe shall be machined flat and true and be fitted with a galvanized cone type strainer—attached by welding—with a total open area at least 3 times the cross-sectional area of the suction pipe.

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(B) Column Pipe Assembly. Column pipe assembly shall consist of the column pipe and the inner column assembly. Column pipe assembly consists of the column pipe and column pipe couplings. Inner column assembly consists of the oil tube, oil tube couplings, oil tube centralizing stabilizers (spiders), line shaft, line shaft couplings and line shaft bearings. Inner column assembly shall be manufactured to Johnston new style type dimensions and threading.

(1) Standards. The column pipe assembly and the materials used in its manufacture shall comply with the most recent revision of the following standards unless otherwise specified:

Table 1202-2
Standards, Column Pipe Assembly

Subject	Standard Designation
Horizontal and Vertical Line Shaft Pumps	ANSI/AWWA E103-07
Column Pipe	ASTM Steel A53 Grade A
Oil Tube	Schedule 80ASTM Steel A53 Grade A
Line Shaft	ASTM A108 Grade 1045 carbon steel PSQ

(2) Design and Construction. Column pipe assembly design shall conform to the following requirements:

- (a) The column pipe shall be sized per the project plans and specifications and shall have a column velocity of ± 5 fps at the design point. The column pipe shall be furnished in interchangeable sections in nominal lengths of 20 feet with a maximum deviation of 0.25 inch, except the top section shall not exceed 5 feet in length. Designs and weights of the column pipe and couplings shall conform to the provisions of AWWA Standard E103-07, Table 3. The column pipe shall be connected with 8 threads per inch (TPI), right hand (RH) straight threaded sleeve couplings. The ends of each section of the column pipe shall be faced parallel and machined with straight threads to permit ends to butt in the coupling.
- (b) Inner column assembly shall be sized per the project plans and specifications and be shipped assembled in nominal lengths of 20 feet. Inner column assembly shall be manufactured to Johnston new style type dimensions and threading. Designs and weights of the inner column assembly shall conform to the provisions of AWWA Standard E103-07, Table 3.
- (c) The oil tube diameter shall provide adequate lubrication under any operating condition. Both ends of each oil tube length shall be bored, faced, and threaded inside to accommodate a butt connection by the line shaft bearings, which also act as oil tube couplings. Each oil tube length shall be

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interchangeable and shall be 60 inches in length with a maximum deviation of 0.125 inch, except the top length, which shall be sized appropriately for the length of the column pipe assembly. The top length shall be designed for application of proper tension to the oil tube.

- (d) The line shaft shall be of ample size to operate without distortion or vibration, and exceed the strength requirements of the torque load provided by the pump driver.
- (e) Line shaft couplings shall be threaded from solid bar stock and provided with a relief hole. Supplied couplings shall provide a safety factor of 1-1/2 times that of the line shaft.
- (f) Oil tube centralizing stabilizers (spiders) of steel-reinforced rubber or neoprene shall be new—no used spiders—and installed to center, and shall also stabilize the oil tube within the pump column. The bottom stabilizer shall be installed within 20 feet of the top of the pump bowl assembly. The top stabilizer shall be installed within 20 feet of the discharge. The intermediate stabilizers shall be installed so that no more than 40 feet separate any 2 stabilizers.

(C) Tension Tube, Top Shaft, and Adjusting Nut. The top length of the oil tube or tension tube shall be designed for application of proper tension to the oil tube. Only tension tubes with externally threaded tops are acceptable. Tubing tension nuts and packing assemblies shall be Johnston type. The top shaft shall be of such length, top threading, and keyway length as to provide easy adjustment through the entire impeller adjustment range. Adjustment threading shall be 10 TPI. Adjusting nuts shall be large steel hex nuts and shall be drilled and tapped for lock screws on 3 alternate or 6 sides. Pumps with shafts exceeding either 1-11/16 inches in diameter or 500 feet of column length shall have a sandwich-type thrust bearing installed between the drive block and the adjusting nut for ease of adjustment.

(D) Sounding Line. A 1-inch, schedule 40 hot-dipped galvanized pipe in 20-foot lengths with couplings shall be installed through the pump head to the top of the bowls in each well. Pipe shall be as per ASTM A120.

The bottom 20 feet of the sounding line shall be perforated with 3/8-inch holes on 2-foot centers, alternating sides, and shall have a galvanized cap. All pipe and perforations shall be deburred.

(E) Well Level Sensing Device. A 1-1/2-inch, schedule 40 hot-dipped galvanized pipe in 20-foot lengths with couplings shall be installed through the pump head to the top of the bowls in each well. Pipe shall be as per ASTM A120.

The bottom 40 feet of the hot-dipped galvanized steel pipe shall be perforated with 3/8-inch

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holes on 2-foot centers, alternating sides, with a galvanized reducing bushing. All pipe and perforations shall be deburred. See plans for installation details.

(F) Foundation Plate. A square, ASTM A36 steel foundation plate shall be provided. The foundation plate shall be uniformly faced on one side, and its size shall be equal to or greater than the size of the base of the discharge head. The foundation plate shall be installed prior to installing the pumping unit. Allow 48 hours for grout to set.

(G) Pump Discharge Head and Lubricant System. The discharge head shall be of ASTM A53, Grade B fabricated steel designed for aboveground discharge with sufficient strength and rigidity to support the motor mounted on it and carry the weight of the attached column and bowl assemblies. The discharge flange shall be faced and drilled to match the discharge piping flanges and pressure class. The discharge size shall be the same size as the discharge piping. All water passages and wetted parts of the discharge head shall be coated with an NSF-approved 2-part epoxy paint system.

The fabricated steel motor plate and foundation plate shall have minimum thickness of 0.500 inch and 0.7500 inch, respectively, and be appropriately reinforced.

The discharge head shall have smooth radiuses on all wetted areas to allow for smooth transition. The discharge flange shall be faced and drilled to match 150-pound ANSI connections. Minimum weights of discharge head assemblies shall be as follows:

Table 1202-3
Discharge Head Assembly Weight Requirements

Size (inches)	Minimum Weight (pounds)
6	290
8	390
10	500
12	600

The discharge head shall have lugs for hoisting capable of supporting at least 3 times the weight of pump assembly under steady hoisting conditions.

The discharge size shall be specified in the project plans and specifications.

The discharge design shall have ample open area to allow easy working access to the shaft, packing, and oil line connection.

The discharge head shall have a hinged safety door with hasp to cover discharge head open area, as well as guard shaft, packing, and oil line connection.

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Tubing tension and packing assemblies shall be Johnston style.

The discharge head shall have a tapped and plugged side drain opening for drainage and cleaning as necessary.

The top of the discharge head shall have a registered fit for mounting the motor driver.

The discharge head base flange shall be drilled with 2 thru holes—one 1-3/8 inches in size, the other 1-1/8 inches—for the level sensor line and sounding line to pass through. The size of these thru holes is such that these lines will hang by threaded couplings. These 2 thru holes shall be welded opposite the discharge nozzle 45 degrees apart.

The discharge head shall be affixed with a stainless steel nameplate displaying the following data:

- Pump make and model
- Number of stages
- Impeller diameter
- Pumping capacity at design head
- Impeller setting

A stainless steel fabricated steel oil reservoir as shown on the project plans and specifications shall be provided and installed. All connecting copper tubing shall curve smoothly downward from the reservoir to the oil flow controller to the line shaft lubrication inlet with no kinks, dips, or sharp bends. All tubing cuts shall be deburred and cleaned prior to installation.

(H) Motor.

(1) General. The motor shall be a vertical hollow shaft squirrel cage premium efficiency motor. The motor shall comply with NEMA MG-1 standards and shall be NEMA WP1 rated. The motor shall operate below the motor's nameplate full load amps for all 3 phases, over the entire range of the pump curve. The motor shall meet the requirements in Table 1202-4 below:

See Table 1202-4 on the next page.

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Table 1202-4
Motor Requirements

Characteristic	Requirement
Horsepower	As specified in project plans and specifications
Speed	Rated motor speed shall be as specified and greater than 96% synchronous speed at rated horsepower
Voltage	460
Phase	3
Hertz	60
Service Factor	1.15
NEMA Design	B
Minimum Insulation	Class F
Ambient Temperature	40° C at maximum altitude of 3,000 feet
Enclosure	WP1
Efficiency	(Minimum at full load)
Full Voltage Start	As shown on plans
Duty Cycle	Continuous
Type	Vertical hollow shaft squirrel cage induction motor

The motor conduit box shall be provided with grounding terminal. The conduit box shall be sized to handle two 3-inch conduits.

Motor windings shall be copper with not less than 98 percent conductivity.

The motor shall be capable of continuous operation at full load and at a voltage 10 percent above or below the rated voltage provided that the sum of voltage and frequency variation does not exceed 10 percent with the frequency variation not exceeding 5 percent.

Motor bearings to be lubricated with grease shall be equipped with grease nipples and grease relief plugs. Thrust and guide bearings shall be oil lubricated, with accessible drain and fill plugs on the oil reservoir. The oil level on the reservoir shall be indicated by a sight gauge. The thrust bearing shall be oil bath lubricated with 88,000 minimum hours L10 bearing life rating at 10,500 pounds pump down thrust, and be capable of withstanding any momentary up thrust produced by the pump.

The motor shall be supplied with non-reverse ratchet, ball bearing type. The ratchet assembly shall be capable of being quickly fitted at any time or removed for servicing without disturbing the coupling or pump setting.

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The motor shall have short commercial tests performed that include:

- No-load current
- Locked-rotor current
- Winding resistance
- High potential
- Vibration
- Bearing inspection

Copies of a test report on the short commercial test performed on the motor model being provided shall be submitted for review as part of the shop drawing submittal. Complete initial test data for a comparable motor shall also be submitted for review as part of the shop drawing submittal, and shall include, but not be limited to:

- Full-load heat rise
- Percent slip
- Breakdown torque
- Locked rotor torque
- Efficiency
- Power factor at full, 3/4, and 1/2 load, running light current
- Power factor at no load, running current at rated voltage

The following information shall be stamped on a permanently affixed, engraved stainless steel motor nameplate:

- Motor insulation class
- Temperature rise class
- Ambient temperature rating
- Design class
- Service factor
- Horsepower
- Number of phases
- Voltage
- Frequency
- Frame size
- Type
- Full-load current
- Full-load RPM
- NEMA nominal efficiency
- Motor power factor
- Motor duty cycle (continuous)

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(2) Motor Data. Detailed data on the electric motor proposed for use on a specific project shall be submitted prior to shipment (when pump curves are submitted). The data shall include sufficient information to verify it meets all electric motor requirements of the project plans and specifications.

(3) Testing. Prior to the field performance testing of the pump and motor, the Contractor shall furnish the following:

- (1) Operating and maintenance instruction manuals for the motor
- (2) Copies of a test report for a short commercial test on the exact motor being provided

1202.0300 EXECUTION

1202.0302 Installation. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the pump drawings.

Qualified supervisory services—including manufacturers' engineering representatives—shall be provided to ensure the work is done in a manner fully approved by the respective equipment manufacturer. The pump manufacturer's representative shall specifically supervise the installation and alignment of the pump shaft with the driver, the grouting, the alignment of the connecting piping, and the installation of the field-installed packing. If there are difficulties in the startup or operation of the equipment due to the manufacturer's design or fabrication, additional service shall be provided at no cost to the Owner. Services of the manufacturer's representatives and training shall be provided when the first pump is started.

Connection of piping to pumps shall be done in the Engineer's presence. All piping connections to the pump shall be done without bending and/or twisting the piping to mate with the pump flange connections.

A certificate from the equipment manufacturer shall be submitted stating that installation of their equipment is satisfactory, that the equipment is ready for operation, and that the Owner's operating personnel have been suitably instructed in the operation, lubrication, and care of each unit.

1202.0303 Pumping Unit Requirements. A stainless steel nameplate embossed with the following pump specifics shall be attached to the discharge head:

- Pump make
- Pump model
- Pump serial number
- Number of stages
- Impeller diameter

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- Pumping capacity at design head
- Brake horsepower required at design head
- Impeller setting

The Tucson Water well name shall also be embossed on the nameplate.

Pumping unit performance criteria shall meet the requirements provided by the project plans and specifications.

Where total discharge head (TDH) is referred to in conjunction with the specified discharge requirements, it shall be understood to consist of the sum, in feet, of the pressure head plus the velocity head at the discharge nozzle of the pump. Pump efficiency shall be understood to be based upon the total head as just defined.

The pump shall operate throughout the entire operating range, within the vibration limitations specified in Subsection 1202.0304.

The pump's horsepower requirements shall be non-overloading everywhere on the curve.

1202.0304 Quality Assurance. Quality assurance requirements for pumping unit assemblies are as follows:

- (1) Pumping unit assemblies shall be provided by the pump manufacturer.
- (2) The Contractor and pumping unit assembly manufacturer shall assume responsibility for satisfactory installation and operation of the entire pumping system.
- (3) Units specified herein shall be furnished by a single manufacturer. The equipment furnished shall be designed, constructed, and installed to operate satisfactorily when installed as shown on the drawings.
- (4) Pumping unit assemblies shall be manufactured in accordance with the Hydraulic Institute Standards, and as specified herein.
- (5) The pump manufacturer shall be fully responsible for the design, arrangement, and operation of all connected rotating components of the assembled pumping unit to ensure that neither harmful nor damaging vibrations occur at any speed within the specified operating range.
- (6) The pump manufacturer shall perform both lateral and torsional critical speed analyses for all pumps greater than 100 horsepower to identify and ensure that:
 - (a) The first lateral critical speed shall be at least 25 percent above the maximum pump speed.

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- (b) No torsional natural frequencies occur within a range extending from 25 percent below to 25 percent above the specified operating speed range.
- (c) Any blade-excited resonant frequency shall be no closer than ± 25 percent of the natural frequency of any part of the installed assembled pumping unit.

Prior to manufacture, a statement must be forwarded to the Engineer indicating that the required analyses have been made and that the specified limitations will be met.

- (7) Vibration, when measured in the direction of maximum amplitude at the top motor bearing, shall not exceed the allowable values established by the Hydraulic Institute ANSI/HI 9.6.4-2000. In all instances, peak-to-peak displacement (vibration) shall not exceed a maximum peak velocity of 0.26 inch per second RMS (6.60 millimeters per second RMS) at any speed within the specified operating speed range.

1202.0305 Testing.

(A) Shop Testing. Each pumping unit shall be factory tested with a Standard Performance Test in accordance with the latest requirements of the American National Standard/Hydraulic Institute Test Standards for Vertical Turbine Pumps ANSI/HI 2.6 – Latest Edition. This non-witnessed certified pump performance test shall be conducted at an RPM equal to that specified in this Section. All test data shall be submitted for the Engineer's approval prior to shipment. Certified copies of the pump performance curves shall be submitted including:

- Pumping capacity (GPM) vs. pumping lift (feet) curve
- Horsepower requirement curve
- Efficiency curve
- Thrust factor (K) curve; data from previous tests of duplicate model acceptable
- NPSHR curve; data from previous tests of duplicate model acceptable
- Required submergence; data from previous tests of duplicate model acceptable

Each pumping unit shall have the linings and coatings factory tested for conformance to the requirement of the project plans and specifications. All linings and coatings that are in contact with water shall be NSF approved.

The motor shall have short commercial tests performed as specified in Subsection 1201.0201(H).

(B) Field Testing. Field tests shall be as necessary to indicate that the pumping unit assemblies conform to the specified head vs. capacity and horsepower requirements; these tests shall be performed in the Engineer's presence. The Contractor shall provide all manpower,

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facilities, power, equipment, and expertise to conduct field testing. Requirements are as follows:

(1) Calibration and Installation. The Contractor shall provide, calibrate, and install all temporary gauges and meters. He/she shall also make the necessary tapped holes in the pipes, and install all temporary piping, layflat, valves, hoses, and wiring required for the field acceptance tests.

(2) Service Representative, Pump Manufacturer. The Contractor shall provide the service of a fully qualified, factory-trained service representative of the pump manufacturer to inspect the installation, witness the initial startup and testing of the pump, and make adjustments as necessary for proper operation. Provisions will be made for the services of the manufacturer's representative for such periods of time as may be necessary to place the unit in satisfactory operating condition.

(3) Vibration Measurements. The pump manufacturer's factory-trained service representative shall field test and measure the pumping unit for vibration in accordance with the latest requirements of the Hydraulic Institute Standards. Vibration shall be measured and recorded with an electronic velocity meter or accelerometer. An electronic vibration analyzer that provides vibration amplitude and velocity for a wide range of frequencies is required. Both vertical and horizontal vibration tests shall be made.

(4) Vibration Limits. The vibration limits of the pumping unit shall be as described in the Hydraulic Institute Standards. It shall be the pump manufacturer's responsibility to dynamically balance the pump and motor, as well as reinforce, stiffen, or support the pump casing, frame, pedestal, or shafting in order to provide vibration levels within the limits described.

(5) Inspection. Prior to testing, all required inspections and adjustments shall be made for proper operation of the pump.

(6) Test Data. After all testing is complete the pump manufacturer's factory-trained service representative shall submit in bound booklet form all pertinent data relating to the pumping units installation and operation, including but not limited to:

- Pump I.D. and location, technician's name, date and time the tests were performed
- Pump serial number, pump make, pump model, head model, impeller diameter, number of stages, capacity and head at design point, and motor horsepower rating
- Measured line shaft runout at the top of motor, as well as inside stuffing box,

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along with a note identifying the maximum acceptable runout

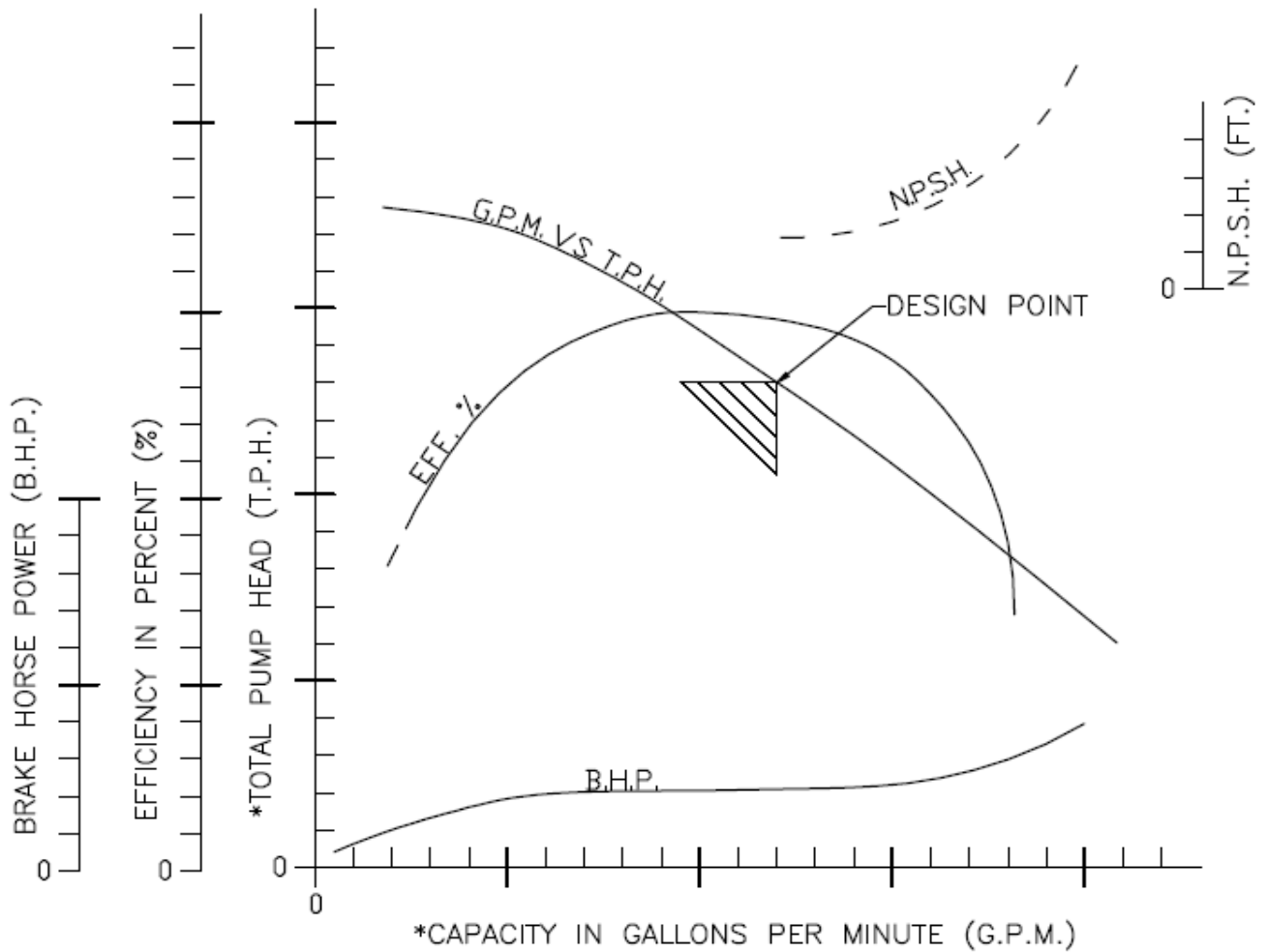
- Impeller lateral in inches and number of nut turns, as well as actual impeller setting in inches and number of nut turns
- Vibration measurement readings at design point, with sketches showing location of readings

This information shall be included as part of the Operations and Maintenance Manual submittals, and shall be provided prior to final project acceptance.

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SAMPLE PUMP CURVE

1. Manufacturer _____	5. Pump Model No. _____
2. Impeller Diameter _____	6. Design GPM _____
3. Design Head _____	7. RPM _____
4. H.P. _____	8. No. of Stages _____



*Range of capacity (GPM) and Total Pump Head (TPH) shall be of the size to properly demonstrate the pump operational characteristics throughout the entire pumping range of the pump. Failure to do so will result in rejection of the pump curve.